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Barriers to Space

“One Giant Leap” for Canadian Early-Career STEM Women

Stefanie Ruel

1. Introduction

Picture the following: you do an internet search on Canadian women scientists or engineers, at the start of their careers, who are working in space. The top two results are links to a webpage on a Canadian astronaut, Dr. Roberta Bondar, or on one or two early-career science, technology, engineering and mathematics (STEM)-trained women who work in the United States (U.S.) National Aeronautics and Space Administration (NASA). Canadian women, who are recent STEM graduates and who are interested in working in space or those who are at the start of their space career, are not often heard from or seen even in this digital age. This is in spite of the fact that the space industry is important to the Canadian economy, generating \$ 5.5B in yearly revenues in 2016 alone (Canadian Space Agency [CSA], 2016). This hidden existence for early-career STEM-trained women is a multilayered one, and is not attributable to any single event or practice. This type of existence in the shadows is indicative of possible barriers to space that early-career STEM-trained women may experience.

Focusing on the U.S. space industry for just a moment longer, the histories surrounding the race to the Moon are more often than not on the military-trained White men and their exploits in space (McComb, 2012; McQuaid, 2007). These men are accorded an almost exclusive hyper-masculine voice with respect to their contributions to Cold War space exploration. Think of Wolfe’s (1979) *Right Stuff* as an example of this hyper-masculine voice. This exclusive voice is in the process of being disrupted with popular media books such as Shetterly’s (2016) tale of African American STEM women as *Hidden Figures* or Weitekamp’s (2004) *Right Stuff, Wrong Sex: America’s First Women in Space Program*. Women who worked on the Apollo program are also coming forward. Notably, Rhoda Shaller Hornstein, an aerospace technologist during the Apollo era, addressed the 70th International Astronomical Congress in October 2019. She talked of her early-career at NASA’s Goddard Space Flight Center, outlining the systemic discrimination she endured, not only at the beginning of her career but throughout her tenure in the industry (Hornstein, 2019). There are also academic studies that are starting to break down these U.S.-based historical space barriers. These works include Ruel et al.’s (2018) retelling of the story of Ruth Bates Harris, the first African American woman hired as a senior manager at NASA in the early 1970s, and Ruel et al.’s (2019) study of White women at the Guided Missile Range Division during the mid-1960s.

Turning back to Canada, STEM-trained women and their role in space exploration are not the subject of much scrutiny in Cold War histories except for a handful of studies (Gosztonyi Ainley, 1990; Herzberg, 2010; Korinek, 2004; Ruel et al., 2020). Canadian women and their contributions are shrouded in obscurity, unknown to both insiders and outsiders of the national and global space industry. For example, the activities surrounding the Alouette I satellite, that marked Canada as the third space-faring nation (Godefroy, 2011), are typically accorded to one hundred STEM men. A single photograph of a woman appears in the media reports of the time; a ‘space princess’ attempting to climb atop an Alouette mockup (see Figure 1). Otherwise, women in Canadian space histories do not seem to exist.



Figure 1: Alouette Space Princess (Brebner, 2014, used with permission)

The cisgender¹ Canadian space industry histories, that divide visible men from the invisible women, are but one of the barriers women face in this industry. Other barriers include limited to no entry-level STEM positions in this industry (CSA, 2013). Women,

¹ Butler's (1990) and Boje's (1991) understanding of gender roles as a socially constructed performance, that adhere to masculine and feminine-ideals, informs the use of this term. I use cisgender and gender interchangeably in this chapter.

a designated Canadian employment equity group (Department of Justice, 2014), also find it difficult to attain management positions in for-profit companies, universities, and in federal government departments that work in the space industry (Ruel, 2019). The few women who do hold STEM management positions appear to be token (Kanter, 1977). Worse still, the lack of visibility into the contributions made by STEM-trained women who self-identify as members of other Canadian employment equity groups, that is Aboriginal/First Nations, visible minorities, or as persons with disabilities (Department of Justice, 2014), speaks volumes to this hidden existence.

All is not lost, however. By shedding light on these barriers, we can actively undo them, taking that proverbial “giant leap”. In this chapter, I introduce the context of the historical and the contemporary Canadian space industry. I also present a framework of discourses and identity intersectionality (Collins & Bilge, 2016; Crenshaw, 1989, 1991) and the methodology I used in this empirical research that will help us dive into the narratives and stories of two early-career STEM-trained women, Geirit and Eliya². I close with a message of hope, inviting you to join others in recognizing and then undoing these barriers to space for early-career STEM-trained women.

2. Canadian Space Industry Context

2.1 Historical Canadian Space Industry

Engineering and science have roots in masculine-dominated military institutions (Hacker, 1989; Royal Military College, n.d.). Along with the goal of instilling rigid military discipline, creating the best engineers, mathematicians, and officers were also central concerns of such institutions (Hacker, 1989). For example, the Military College of Canada, founded in 1874, was and continues to be focused on training officers in military tactics and fortification, as well as on engineering and objective scientific knowledge acquisition (Hacker, 1989; Royal Military College, n.d.). It is noteworthy that this Canadian military college system specifically excluded women from entering its halls until 1979. Hacker (1989) argues that the military provides the first instance of a structured, masculine-ideal hierarchy for those learning within the engineering and science professions. She similarly argues that military engineering serves to maintain occupational stratification along cisgender lines.

There are important influences from the military in Canada’s efforts to explore space (Gainor, 2006; Godefroy, 2011). Notably, the Defense Research Board (DRB) and the Defense Research Telecommunications Establishment (DRTE), home to the Alouette satellite program, were organizations focused on establishing reliable communication over long distances by studying the ionosphere. These types of scientific and engineering

² These are pseudonyms to protect these individuals’ identities.

efforts came to prominence during World War II, and thereafter during the Cold War. In particular, Dr. John H. Chapman, a former radar officer in the war and a physicist trained at Western and McGill Universities, along with two colleagues at the DRTE led important discussions with their counterparts at NASA regarding studying the ionosphere from space (Green, 1957). To Dr. Chapman's credit, he did try to hire qualified women scientists to join his team, succeeding in convincing others to bring women onboard as student trainees (Chapman, 1958), such as Doris Jelly (Gainor, 2006), or as full-fledged staff members, as is the case with Dr. Luise Herzberg (Herzberg, 2010).

In spite of these efforts, the one-hundred men involved in Alouette I are the ones celebrated today, to the detriment of the more than one-hundred and twenty women (Ruel et al., 2020) who also worked on this initiative. Such names as Frank T. Davies, Dr. Chapman, Colin Franklin, David Florida, Philip Lapp, Leroy Nelms, Keith Brown, John Mar, and George J. Klein, to name just a few of these one-hundred men, are rightfully recognized for their important contributions to Canada's foray into space. However, names like Dr. Herzberg and Ms. Jelly are not celebrated or known. Dr. Herzberg was able to produce an impressive body of knowledge for the DRTE. She was one of the last Jewish women accorded a PhD degree in Germany before the start of World War II, and following her and her husband's escape from the Nazis, she managed to cobble together Canadian summer student positions into the late 1950s while also raising her two children and looking after her parents and her in-laws effectively on her own. Her work, in solar spectroscopy and limb-center displacement of infrared solar lines, and then her focus on low-earth orbit and Alouette data analysis (Herzberg, 2010), seems to be lost in these masculine-centered Canadian space histories. Similarly, first hired as a summer student working on data analysis at the DRTE in 1953, Ms. Jelly later became a full-time physicist at DRTE in the Radio Physics Laboratory (RPL). The RPL was concerned with "basic studies of the upper atmosphere, and particularly with the disturbances that result therein under the influence of charged particles from the sun"³. Ms. Jelly, at the time a member of the Canadian Association of Physicists and the American Geophysical Union (N.A., 1969), is still active at the time of writing, ensuring that Alouette and other important scientific work accomplished by the DRTE are not forgotten. Ms. Jelly does acknowledge, during interviews with her, that she was surrounded almost exclusively by military men within DRTE; she does, however, recall working with Dr. Herzberg. Ms. Jelly also recalls, which we later confirmed via archival research, that she oversaw a number of women in technical positions including scalers in the Upper Atmospheric Physics Section. These women would "scale", or retrieve information from the Alouette

3 To facilitate archival references I am putting this one in a footnote. This quote is attributable to Library and Archives Canada, Box MG 31 J43 Vol 3, file 1960–1965 DRTE Scientific and Administrative Organization guides, DRTE Scientific and Administrative Organization, DRTE Publication No. 1037, January 1960, p. 3.

ionograms, and then they would investigate large numbers of these ionograms, looking for particular features (Ruel et al., 2020).

2.2 Contemporary Canadian Space Industry Context

The Canadian space sector took formal shape following the 1990 proclamation of the *Canadian Space Agency Act* (CSA, 2015b). The CSA, the brainchild of Dr. Chapman, is responsible to the Canadian parliament with respect to spending, ensuring that space initiatives are funded and that all activities comply with various legislations in place. The CSA is at the center of what is considered non-military efforts in coordinating, financing, and promoting the Canadian space sectors (Godefroy, 2017). While it is beyond the scope of this chapter to present all of the CSA's responsibilities, the organization does provide access to key space resources, such as the International Space Station and other microgravity vehicles, via extensive formal rules and international partnerships. In addition, there are over one hundred and fifty for-profit companies, universities, and government departments in the Canadian space industry, with "the top 30 space organizations generating 97% of total space revenues and 79% of space employment" (CSA, 2016, p. 6). Many if not most Canadian space initiatives continue to be conducted by privately-run organizations, such as MacDonald Dettwiler and Associates (MDA), and universities such as McGill University and York University.

Individuals who work in this industry handle important science, technology, and engineering challenges that untrained STEM individuals would find challenging to address. Specifically, the global workforce of space professionals is recognized in the literature as being resilient, and able to weather a number of cancelled programs that exceeds completed programs (Allan, 2004; Lang et al., 1999). These STEM-trained individuals are also able to master communication skills beyond the technical (Lang et al., 1999). They also have a capacity for working through tremendous amounts of paperwork (Allan, 2004). Significant challenges to working interdependently also characterize this industry, notably for individuals in the Japanese Space Agency or the Russian Space Agency as compared to those who work with the European Space Agency, NASA, or CSA (Sandal & Manzey, 2009). In their study of active duty and retired astronauts, and of international space agency personnel, Lozano and Wond (2000) identified fourteen cultural factors that affect work in this industry. Traits, such as humor, were highlighted as necessary given the long hours of intense work. However, culture may dictate what is considered funny for one and not for another. Lozano and Wond (2000) also noted that cisgender can affect role interdependence in space; cisgender roles, norms, and stereotypes can create tension and conflict among crew members.

The outcome of contemporary occupational stratification along cisgender lines is an ongoing issue and continues to be the subject of a number of studies (e.g., Cardador, 2017; Cardador & Hill, 2018; Hewlett et al., 2008). Specifically, Canadian STEM-trained women represent fewer than 20% of managers across the Canadian space indus-

try (CSA, 2012; Catalyst, 2013). One of the largest private space organizations, MDA, has a history of contributing important work in the Canadian space industry dating back to 1969. In 2012, they had no women in senior officer positions out of a possible eight positions (Catalyst, 2013). At the time of writing this chapter, MDA had undergone a number of mergers and acquisitions including finding itself under the U.S. banner of Maxar Technologies Inc. (Byers, 2017). Under Maxar, MDA had two women on its board of directors: Roxanne Decyk; and, Joanne Isham (Maxar Technologies Inc., 2019). Another private company, Calian's SED Systems, a small space organization established in 1965 (Calian Ltd., 2019), has an executive made up entirely of eight White men (Calian SED Executive Team, 2019). As for the CSA, in 2015, 22 % of the scientific and professional workforce positions were held by women (CSA, 2015a). From my personal experience in this organization until late 2016, only one executive position was held by a White /French Canadian /mother with a PhD in engineering. This translates to an 8.33 % representation rate for women in scientific executive positions at the CSA.

With this historical and contemporary Canadian space industry context in mind, I now turn to the framework of discourses and identity intersectionality. Such a theoretical framework is important to consider at this time, as this structure helps to support the empirical findings that I will present later in this chapter.

3. Framework of Discourses and Identity Intersectionality

Empirically speaking, there are few discourses by and of STEM-trained women in the technology industry or space industry that are published. If there are any, these discourses are tales centered on what to do and how to act like the masculine-protagonists in question; think of Sandberg (2013), who extols 1960s liberal feminist norms in the technology industry. I believe that we need to hear about day-to-day practices with the rose-colored glasses removed. Painful, mundane, and triumphant discourses need to be shared in such a way to influence and to transform the social interactions in organizations. Ultimately, I don't want to be part of a silent majority that helps to maintain barriers to women entering and being part of the space industry.

The concept of discourse, as I use it in this chapter, reflects "everyday attitudes and behavior, along with our perceptions of what we believe to be reality" (Grant et al., 1998, p. 2). Discourses can be constructed as sets of statements and practices that bring an individual, or sets of individuals, into being within a larger context of meanings (Parker, 1992). This idea of melding in larger meanings through discourse offers us a way of restructuring the social, where we can make sense of everyday events by telling and retelling these broader meanings within stories and narratives, two tangible examples of discourses. Stories engage, excite, frustrate, and can make one mad. The emotions conveyed in shared stories draw you in, making you part of that story. Stories can also reveal values, rules, and boundaries (Saleebey, 1994), without the individual necessarily

recognizing these stories in such a way. Narratives, on the other hand, inform the present and guide the future. They are widespread, attentive to form and style, and often relate to prototypical matters (Saleebey, 1994). In essence, “they instruct, chasten, and lend rhetorical weight to norms and conventions” (Saleebey, 1994, p. 354). Examples of narratives include interpretations, arguments, and opinions which lack plot, characters, and action (Gabriel, 1998). Stories, to be clear, are not the same as narratives. Stories are more loosely organized and more idiosyncratic than narratives. Furthermore, stories typically focus on a single event with the goal of entertaining, inspiring, and educating (Gabriel, 1998).

Stories and narratives do draw on who we are and who we want to be, or our identities. This centrality of identity, as Thurlow (2007) found, can be teased out of stories and narratives, and the making of sense of these discourses, to reveal an individual. This centrality of identity is, however, not fixed or stable in these discourses as we continually make sense of events and experiences, and of who we are (Helms Mills et al., 2010). Our identities ebb and flow throughout our discourses, in other words. As a result, discourses are plausible in the moment they are told, and our interpretations are also plausible in the moment that we interpret them. This plausibility does not imply, though, that identities will not or cannot change in the future.

This concept of identity and its centrality comes to us from many different schools of thought. It is beyond the scope of this chapter to consider all of these; a high-level introduction to ‘who I am’ is required in order to understand what the stories and narratives of Geirit and Eliya are going to tell us. The self – ‘who I am’ and ‘who I am becoming’ according to Mead (1932, 1934) – is constructed around a sense of identity that each of us possesses as a result of social activities and events. This self comes to light through our capacity to use language, to assign meaning to the narratives and stories, and to reconstruct an image of ourselves in social interactions (Anderson, 2016). The self is (re)created in our ongoing “adjustment and adaptation” (Anderson, 2016, p. 179) through discourses experienced in those social interactions. Discontinuities in the social allow the self to (re)create fragmented stories of ‘who I am’ and of the positioning that can occur in social interactions.

The concept of identity, within such a framework of the self, can be constructed along self-identity and social-identity lines. Self-identity is the “notion of who he/she is becoming” (Corlett & Mavin, 2014, p. 262). This concept also permits us to explore self-perception as a question of ‘who I am’. For example, my perception of ‘who I am’ includes being a French-Canadian and depends on the social world I find myself in. For example, June 24th is the *Saint-Jean Baptiste* holiday in Quebec, a nationalist cry for the *Québécois* (masculine)⁴ to embrace their cultural, independent status. In this milieu, I would not state that I am French-Canadian but rather *Québécoise* (feminine) to avoid

4 Typically, the masculine is a discursive norm used in French to embrace everyone in society.

possible political – or bodily – harm. While my discourse is different, I still reflect my cultural heritage as being part of me, of who I consider myself to be. This example surrounding my self-identity is also an example of a resistance discourse; I actively choose to politically name this self-identity, depending on the context I find myself in, to fit a social world with its own cultural norms and rules that I navigate on a daily basis.

Social-identity consists of ‘inputs’ into this self-identity (Watson, 2008). These inputs are socially constructed; that is, they involve an experience, a history, or a position in society that is external to and coercive to the individual (Anderson, 2016). Attachments, such as emotional involvements, can also be considered inputs (Ashmore et al., 2004). Social-identities can be manifested in and influenced by discourses. For example, when I worked in the Canadian space industry, my occupational social-identity was Life Sciences Mission Manager. This social-identity reflects a position in society; that I was employed, that I was STEM-trained and knowledgeable in the field of life sciences, and that I was socially categorized within the Canadian space industry. The difference between self-identity and social-identity in these two examples is that my self-perception is one of being French-Canadian, but my social-identity of Life Sciences Mission Manager was assigned or attributed by an organizational structure that said this was ‘who I am becoming’.

The ephemeral and changing states of identities are both fascinating and a bit daunting to analyze, especially when we meld in identity intersectionality into this framework. Intersectionality, coined by Kimberley Crenshaw (1989, 1991), is concerned with addressing identity categories (cisgender, race, class, etc.⁵) that are interdependent and that constitute each other. These intersecting identities change through time, context, and social interactions (Calás et al., 2013). Empirical research conducted by Crenshaw (1989) and Collins (2000), along with many others (e.g. Calás et al., 2013; Van Laer & Janssens, 2014), demonstrate that complex identity intersections can position individuals in society, creating an order often manifested as discrimination. This order, reproduced in discourses, can position the complex individual along their intersecting identities, erecting a variety of barriers. For example, someone may identify a Black woman who is dependent financially on her partner. She is, in other words, not ‘just’ a Black woman, or ‘just’ a woman, or ‘just’ a financially dependent woman; she is an amalgam of all these identities. An anchor point, a financially-dependent Black woman, is a temporary and fluid construction of this individual’s self (Ruel, 2018). This anchor point highlights not only the intersection of race, cisgender, and her socio-economic status but also that an order exists; that is, this financially-dependent Black woman is positioned below her partner, perhaps an employed Black man. Empirically, such an

5 Fourteen possible identity categories were identified by Lutz (2002): race or skin color, (cis)gender, sexuality, ethnicity, class, culture, religion, age, able-bodiness, migration or sedentariness, national belonging, geographical location, property ownership and status in terms of tradition and development. I choose to identify three categories with an ‘etc.’ at the end for writing economy purposes only.

individual has been shown to be treated differently than a White woman or a Black man within a legislative context (Crenshaw, 1991) or within other social realities (e.g. Bowleg, 2008; Ruel et al., 2018).

Anchor points are a sub-branch of social-identity. They are temporary, fluid, intersecting, influenced by and through social interactions, and are attributed through discourses (Glenn, 2004; Ruel, 2018). The exercise of identifying anchor points is not to generate an exhaustive list; instead, it is to plausibly understand these positionings and to begin to undo unjust social orders that support these positionings. With these concepts in mind, I now turn to the research design I used to capture, extract and analyze Geirit and Eliya’s discourses.

4. Research Design

The overall participant sample recruited for the study on STEM-professional women in the Canadian space industry was diverse.⁶ I drew from a range of STEM-education levels (i.e., bachelors, masters, PhD), professional and occupational roles (i.e., executives, managers, engineers, scientists), Canadian-specific career stages (i.e., early-career [under 5 years], mid-career [over 5 years but under 15 years], late-career [over 15 years]), and types of Canadian space organizations (i.e., public and private). I organized the participant sample by career stage, as I found this scheme helped me to trace the individual and her experiences. Interestingly, this categorization led to themes emerging from all collected data, and resulted in this chapter on early-career STEM-trained women. Table 1 summarizes some of the demographic information for these early-career women.

Career Stage	Name	Cisgender / Ethnicity / Cultural / Sexual Preference	Profession / Education	Marital Status / Family Status
Early	Geirit	Woman / White / Anglophone (Canadian) / Sexual orientation not defined	Tech Lead / Senior Engineer / PhD	Single
Early	Eliya	Woman / White / French (European*) / Heterosexual	Employee* / Junior Engineer / master	Single

* To protect the participant, some of her specific cultural, professional and academic identities are not shared.

Table 1: Early-Career STEM-Trained Women and Their Intersecting Identities

6 The complete research initiative on STEM-professional women’s exclusion in the Canadian space industry can be found in Ruel (2019). This chapter is based on two participants from this larger study; they and their stories are presented in a more in-depth fashion in this chapter and are framed for a particular audience.

Data collected included the participant's narratives and stories and a variety of documents, including participant e-mails and publicly available corporate reports. I chose to specifically use unstructured interviews with the participants following quantitative and qualitative empirical studies that show that identities are best left to the individual to identify through their own voice (Ashmore et al., 2004). The option to conduct the interviews in French or in English was offered as this reflects the bilingual reality of the Canadian space industry. This option to be interviewed in French or in English also takes into account Pavlenko's (2001) call for the inclusion of bilingualism in research.

The interviews were tape-recorded and maintained in three separate physical locations, each with separate password protection. A copy of the recorded interviews was provided to two professional transcribers. Interviews were either transcribed directly by one professional transcriber when participants chose to speak in English, or the interviews were translated and transcribed from French to English by the other professional transcriber. This French-English live translation/transcription was a viable financial option, given the experience of this professional transcriber and my own bilingual experience in this industry. The resulting transcriptions and other collected documents were similarly kept in three different physical locations and were password protected.

I focus, in this chapter, on the narratives and stories that Geirit and Eliya used to construct both their occupation and their self. To be able to find and then share these narratives and stories, I analyzed the transcripts and extracted those narratives and stories that would interest an audience of undergraduate and masters-level students. I also analyzed the transcripts in such a way to (re)construct Geirit and Eliya's complex selves. Specifically, I looked for discourses that revolved around self- and social-identities as well as their anchor points, asking myself repeatedly what a reader would want to know about these women and about their experiences in such a way to better understand the daily barriers these women faced. I also surfaced dominant practices, values, and rules that this audience would want to know about. I did this as a way to shine a light on various hidden elements of this industry. I turn now to these findings.

5. Early-Career STEM-Professional Women in the Canadian Space Industry

5.1 Geirit

Geirit's stories and narratives reveal some aspects of 'who I am' along with 'who I am becoming'. She emphatically self-identified as someone who never wants children, also labeling herself as "long term single": "I never had any interest in having kids, so that's not an issue either. I think if you don't want – if you actively don't want – kids, it sort of changes the importance of all that." She did not identify her sexual orientation, choosing to leave this unspecified during our conversation. She also self-identified as someone who

is very hard working. She underlined that she “needs change,” comparing a number of times where she used to live – a beautiful European city – to where she lives now, a place that is anything but beautiful:

I don’t know if you’ve been to [specific city]? It’s kind of a hole. [...] I was coming from [a specific European city] and just small towns in North America. Great if you want to live, you know, raise a family or something [in the specific city that is a hole]. Just not what I was looking for. So, I got to the point where I was like, “I am really not happy here. I need to change,” and I was starting to think about looking for a new job.

Her social-identities are influenced by ideologies relating to her academic credentials, occupations, and social attachments. Geirit is internationally educated, with an undergraduate and a master of science degree. She also holds a PhD degree for which she developed a prototype flight hardware. She is recognized internationally as an engineer but not within the provincial Order of Engineers where she works. This subtlety is important given previous research done by Porter (2013) on the Order of Engineers, a professional association that certifies engineers to work in various engineering fields. Specifically, Porter (2013) found empirical evidence of sexual harassment and sexual discrimination in this Order. In Geirit’s case, she did share her experiences with me regarding her provincial Order. Notably, that a colleague, who is a man with a similar undergraduate background as hers, was asked to write only the ethics exam for the Order. She, on the other hand, was asked to write seven technical exams at the cost of \$ 500 each. This experience highlights one example of what appears to be a gendered educational barrier to joining the Order of Engineers in this particular province, and how this could impact Geirit’s social-identity (i.e., not recognized as a ‘professional’ engineer) and her career progression potential in this province.

With respect to Geirit’s occupational influences, she works within a private Canadian space organization, the Hexagon Company. She states that:

My first job [for Hexagon] was to interface between the engineering teams and the customer. They were looking for somebody with an education in physics and experience in their aerospace field. [...] I do anything from initial concept studies, proposal work quite a bit. So like a lot of early-phase program work where its orbital mechanics or its requirements definitions. I’ve been tech lead on a number of programs, and then the other half of what I’ve done is a lot of systems testing. [...] And now I work at operations, so I have a lot of experience in the beginning and the end, from a systems perspective.

Geirit finds that technical work, by those in a technical position, at this Hexagon company is done mostly by men, while women represent the “standard 20%” in technical positions: “There is one functional manager for software who is a female. The other managers are all male. It’s your pretty standard 20% of the personnel is female.” Geirit also gained some STEM work experience beyond Canada’s borders:

Well, for the first six or eight months [after my PhD] I was looking for a job and then waiting for a Visa. I did my PhD in [specific European country], decided to go back to [Europe],

worked [for another company]. I was a subcontractor too [at another company] for about a year and a half.

Even during her short tenure in the Canadian space industry, Geirit experienced many organizational changes. Some of her stories highlight challenges that some early-career STEM-trained individuals can face with respect to attachments, and the need to develop resilience in the face of such relentless changes:

Well, over the past years, there's been a couple restructurings within [Hexagon] before [this latest change]. And since [this latest change], there's been, you know, upper management of course moved on. There was a few layoffs. [...] [That group that I was a part of] was only like a year and a half old when I joined. Since then, it sort of dissolved back into the bigger part of [the company] [...] And now that [this latest change has happened], everything's sort of getting shifted around; it's still in flux.

I'm now on my third manager since I got hired [...] There was a bit of a restructuring. His group was me and another girl. She – I think she got laid off in one of the rounds of layoffs – and just as a whole our group got smaller [...] That put me under a different manager. He resigned, and that group has sort of re-formed a couple of times, but basically that group reports to the person that was his manager [...] [This latest change happened], so who knows what's going to happen with that.

As a plausible explanation for surviving such extensive changes, the idea of merit seems to be at play for Geirit. This merit ideology appears to be embraced by women in this industry as Faulkner (2000) and Morgan (2000) found. Technical know-how, in particular, is used extensively in Geirit's stories and narratives. Geirit does talk to working in diverse projects, with minimal supervision and with growing responsibilities. She is recognized as a "technical lead," building on these experiences and on her skills to gain this elusive merit.

A subset of her social-identities, or her anchor points, reveals her positioning in this industry, along with some of the daily barriers she faces. Starting with 'The Bitch' anchor point, Geirit recounted the circumstances surrounding this positioning:

I'm probably known as a bit of a bitch; I've lost my patience with people that just can't do their job. So not the manager that hired me but the manager after him, we worked together on [specific project] [...] and he didn't really see eye-to-eye with the rest of the team, and I was the most outspoken member of that team [...] He and I butted heads quite a bit [...] We were always arguing: "Why are you worried about that?" "That's not a problem" or "Why aren't we doing it this way?"

She found herself, at times, having to underline that she is 'The Leader' – another one of her anchor points – while wondering why she was forced to do this. 'The Leader' anchor point reflects different organizational behaviors, such as influence, vision, and motivation (Bratton & Chiaramonte, 2007) more so than, say, the gendering anchor point of 'The Bitch'. In spite of the risks associated with working in an unstable environment,

Geirit continued to resist day-to-day interactions that attempted to, in her words, “put her in her place” as ‘The Bitch’:

There’s another guy in that program [...] He had like 40 years of experience in the space industry, so he knows a lot, has a lot of experience and he would sometimes talk like, “We’re going to do this,” and there were a couple of times where I had to be like, “You know, I appreciate your input but we haven’t decided yet, and even that’s not really your decision to make, but, you know, don’t stop giving me an input, but that’s not your [hesitates] you know, I’m leading the program.”

I do have annual performance reviews and sometimes these sorts of things [overstepping my bounds, being ‘The Bitch’] come up.

I was thinking of a specific instance where I had basically said to this guy, “Thank you, but that’s not your role” in front of a room full of people! And then I went and asked my functional manager if that was overstepping my bounds because, you know, a) outside perspective, and, b) somebody with more experience than me – my senior.

These stories and narratives showcase some of Geirit’s struggles in her day-to-day social interactions. In the first passage, she did not hesitate to forcefully stand her ground, embracing ‘The Leader’ anchor point in spite of interacting with a colleague well beyond her years of experience. In the second and third passages, she struggled with ‘The Bitch’ anchor point, wondering if she had overstepped her bounds. Historically, women who try to lead are indeed labelled ‘The Bitch’ (Mavin, 2008). While there is no evidence that Geirit is being ‘The Bitch’, she is clearly assertive, knowledgeable in her field, and has been assigned programmatic mission responsibilities. It is plausible that Geirit may be trying to conform to the masculine-dominant culture in order to survive in the everchanging environment she finds herself in. She is trying to “walk a very fine line between being ‘like’ the valued-masculine prototype” (Miller, 2004, p. 68) – assertive technical lead – while also navigating what she calls her “female-ness” via ‘The Bitch’ positioning.

Linked to this “female-ness” is the ‘Females are More Serious’ anchor point, which surfaced in numerous stories about her educational and work experiences. The following story showcases this anchor point:

So, I’m there [in a European country] for a couple years, and everybody that started after me was female and I said flat out to one of the managers: “This is weird. Why [...] I mean, I know what the statistics are – the number of [females] in school – right?” And he told me that: “we prefer to hire females because we find that they’re more serious about their work than the guys are.”

She emphatically and forcefully stated during our interview together that her “female-ness” has nothing to do with her abilities and skills: “that’s just ridiculous. If I had been in a different situation when I got hired, I might’ve considered quitting based on that! I don’t want to be hired based on that.” Another brief narrative, reproduced below, introduces another facet to this “female-ness”: “they knew me; they had seen my work [...] so, that’s positive toward females, but I don’t want to see that.” Here, Geirit admits

that she doesn't want to see that her "female-ness" has anything to do with her work. Her ability to do her job, her knowledge, her training, etc., – in other words, her merit and skills – needs to carry her work and not her "female-ness". Furthermore, Geirit appears to have a cisgender understanding of merit and skills with respect to her expectation for "reasonable" career progression:

Geirit: I can't picture myself being happy, doing the same thing for 20 years. So, whether it's up or sideways, I'm interested in going where it's interesting, where I can be useful, where I can be good at what I do [...] I feel like you can go toward management, but it's hard to go back toward technical if you haven't been doing something technical for 10 years [...] My management's always given me positive feedback. You know, that's a reasonable expectation [to become a manager] for me. Let's put it that way.

Interviewer: Are they helping develop your management potential?

Geirit: Specifically, management potential? I would say not yet. Leadership potential, I would give you that. [...] I'm fairly outspoken, so I think it falls naturally that I go into that role as a leader.

Her "technical lead" positioning helps her, she believes, to develop her eventual managerial abilities. She also interprets positive feedback in her appraisals as signs of a "reasonable expectation" that she will become a manager. Importantly, however, her management potential is not being developed by the organization, or, from what I could tell, by her. What is being developed is her ability to embrace 'The Leader' anchor point. Specifically, she is following what she believes to be a reasonable progression: developing technical skills/merit, embracing 'The Leader' identity, and then "naturally" or "organically" becoming the manager. These expectations for progress run counter to the demographic realities of this industry, where STEM-trained women rarely become managers in spite of their strong technical skills and merit.

5.2 Eliya

Eliya self-identifies as very hard working, wanting to be the best at whatever she does, to the point of compromising her health:

I expect a lot of myself and from others too – which isn't bad – but I'm always disappointed by the work.

I gave my all when I was a student and I don't want to study anymore. There was a year where it wasn't working out; yeah, I wasn't feeling it, and I wasn't very good. I had to be top five of 160. I ended up with three ulcers. That was horrible!

Similar to Geirit, Eliya stated that she does not want children: "No, I never really wanted any [children]. People always said, 'You'll see when you are 30,' and I'm [specific age] now. 'You'll see when you're 30; it'll hit you like a ton of bricks,' but, no, it hasn't changed yet." In her narratives and stories, Eliya appears to offer more of a back-and-forth inner dialogue than a definitive statement on 'who I am'. This is interesting from a sociological

perspective, as it showcases that her self-identities are, indeed, fluid and subject to influences not only from internal dialogue but also from external interactions.

Eliya's social-identities seem to reflect understandings such as those discussed by Pavlenko's (2001), with calls to include language⁷, academic credentials, occupations, and her gender. With respect to the influence of language, Eliya specifically requested that the interview be conducted in French. This is important, as it underscores a cultural ideology that helps define her social-identities. Significantly, she began her interview by sharing a defining moment for her:

So, even before university, there was an experience that really had an impact on my life: I went to the United States at 16 to learn English. Before that I liked to travel, but for this trip I went alone, at 16 [...] After that, I told myself that I needed to pick a field that would allow me to travel in addition to following my passion for space, something I've been wanting to do since I was very little.

Eliya was able to follow her passion for space, graduating with a master's degree after passing through a "prestigious" European system of education:

For my Lycée, I studied in [specific European country]. I was a good student. In [this specific European country], there's a stream you can take when you are good in math and physics – very elite. So I applied to that.

I went to an engineering school. In [specific European country], there's a specific branch for engineering, with a specialization in space and aeronautics. [...] I worked hard. Only the best get to go, so I worked hard to be one of the best and have the opportunity to do this double diploma. So I did two and half years in [Europe] and two years in the U.S. Both diplomas were in aeronautics and space, and in the U.S. it was a master's of science, for which I did research during a year and half.

We also discussed her movement in different jobs through her international experiences:

My last year of studies in the U.S., I found work in [Europe], as a consultant. I was a subcontractor for [specific space company], and there I validated the flight software for [specific] satellites. My contract was up after a year, and the company for whom I was working wanted to transfer me over to a different department that wasn't my thing [...] So I left. I looked at international postings because I was ready to leave, and I found something in Germany at [another specific space company], the company that does European [specific space missions]. So we [my boyfriend and I] applied to aerospace jobs in South Africa, Argentina and in Canada. I found my current job here in Canada, so we came to Canada. During that phase, between Germany and Canada, I worked for three months for the [specific] Space Agency.

⁷ I chose to focus on French as a cultural ideology. I could have also done the same for English interviews; however, those participants that spoke English did so without clearly identifying this influence while French-speaking participants made this an explicit request.

Eliya did find it challenging to find a position after her first contract:

It's hard to find work. Apparently it's getting better, but in my experience, when I decided to leave again, it was because I couldn't find anything in [a European country]. I also wanted to leave, but I spent a month and a half looking full-time, sending CVs out six hours a day, and I got no answers. Not even a 'no'. No interview, nothing.

She now works within a private Canadian space organization, the Octagon Company, and has diverse responsibilities:

I was working only for [specific manager] in [specific satellite] operations until January [2016]. Since January, I've changed to the development of [specific] operations. I got the offer in September. The posting was for [specific location], and I really wanted to move there, but the conditions that were offered were [hesitates] a bit tough.

I was a project lead last year, managing the budget, the planning, the training for [specific country]. So, I was project lead on that, coordinating the trainers, building the course programming, and all that. I liked it a lot – the subject, the training. I love what I do.

Eliya shared that she is not “career-oriented” and that there is a lot of change in the particular organization she works for:

I'd like to leave for a year and really take advantage of discovering new things. [...] I imagine becoming an expert and maybe do consulting one day in satellite design. I'd really like to work in South America one day. There's the aspect of work that is actually fascinating, but there's also the discovery of a new country and culture. I really love that.

At the moment, there are lots of people leaving. Two just left, and there are apparently two others who want to leave.

With respect to her gender, Eliya also touched upon her heterosexual relationship with her boyfriend. Specifically, she had to make various choices with respect to her career where she deferred to her boyfriend's wishes:

I looked at international postings because I was ready to leave, and I found something in Germany [...] That would have worked for me, but in the meantime, I met a boyfriend who didn't want to go to [there], so I said no to this offer.

The posting was for [specific location] and I really wanted to move there, but the conditions that were offered were [hesitates]. Well, not in the state I was in. My boyfriend and I had separated.

This idea of deference is important to consider as an ideology that can influence women in the space industry. As Ruel et al. (2019) presented in their historical study of White women who worked in the U.S. space industry in the 1960s, women were expected to leave their careers to marry or to have children. I am talking to this influence on Eliya's social-identities not as an admonition but rather as an observation that these types of cisgender choices – those between romantic relationships and work – continue to be made by women in the space industry even today.

Among Eliya's range of anchor points, I am focusing on a select few of them in this chapter; notably, the 'Not Very Serious' / 'You're so Funny' and the 'The Only Girl'. I found myself attributing the 'Not Very Serious' / 'You're so Funny' anchor point to Eliya, during the interview, without realizing I was doing so. I was mirroring what others had done in her daily interactions and we discussed it further together:

It's spontaneous; lots of other people said it [being refreshing/funny] could be harmful, but not so far. I think something I discovered here – one of my strengths – is that I don't stress over losing my job, and that allows me to [hesitates] I tell myself that it doesn't matter if it doesn't go well; there are [other] things I can try.

This particular anchor point was challenging to extract from transcripts, and then to analyze, because I could easily categorize it as a self-identity, so prevalent it was during the interview. Eliya played with this 'Not Very Serious' / 'You're so Funny' identity, at times unsure of it. Given my own impulse to attribute and use 'You're so Funny' with her, and her uncertainty about attributing it to herself, it is plausible that this identity is not yet a self-identity.

This 'Not Very Serious' / 'You're so Funny' anchor point also relates, importantly, to another aspect of women's experiences in this industry. Women are targets for men's teasing and, in light of this value, Eliya recognizes that she needs to be "adaptable" within this masculine-dominant context:

There were so many times that, well the others were a bit rough around the edges. At lunch, I'd get corks thrown at me. One guy came to me and told me he was watching me all day – yeah, that was a bit [hesitates]. Some were very cultured, knew lots of things, but not educated in terms of good manners [...] It still left an impression on me. We sometimes had Italians who [...] who had come, and they had pulled that on [specific woman's name], checking her out from head to toe. She was furious. And me, I barely noticed. That's how it is for me now.

From the literature, Powell et al. (2009) found that within engineering professions, women perform by accepting these types of gendered jokes and teasing as a way to get by. Linked to accepting such practices is the ability to endure them. Eliya's ability to withstand the teasing is, arguably, found within her 'You're so Funny' anchor point. This anchor point disarms others in a way that is novel, with a focus on what she calls "fun ways" of undoing the positioning she faces on a daily basis.

Earlier in Geirit's experiences, we gained some insight into the unstable work context she found herself in. Eliya's shared experiences also underscore this instability. What differentiates Eliya from Geirit is Eliya's approach to this instability. While Geirit internalized the "need for change" into her self-identities, Eliya seemed to make sense of this instability through her anchor point of being 'Not Very Serious': "the worse that can happen is that I leave and find something else [...] It's no big deal if you fire me; I'll have some time off! [laughs!]; "After [specific program], I'd like to leave for a year

and really take advantage of discovering new things.” These brief narratives, along with others, appear to be repeated calls to taking time off, planning for travel, etc. Through these shared discourses, I was able to gain a better understanding of how Eliya could be attributed the ‘Not Very Serious’ anchor point: if she consistently shared with others in the industry a wish to “discover new things” or a plan to take “some sabbatical leave to travel,” colleagues would start to question her commitment to the industry, reflecting this in her ‘Not Very Serious’ anchor point. Alternatively, these repeated calls to leaving the industry could also be interpreted as a resistance discourse. To protect herself from the ever-present and tangible prospect of losing her job, Eliya chooses to embrace this anchor point by using a devil-may-care attitude with respect to her job.

The demographic reality of the Canadian space industry, as I presented earlier, supports the emergence of another one of Eliya’s anchor point, ‘The Only Girl’: “in the U.S., there were classes where I was the only girl. Or we were two among 30.”; “and, yeah, I was pretty much the only girl, and there were so many times that, well the others were a bit rough around the edges.” Eliya also did acknowledge that most meetings or social encounters reinforced her sense of being “The Only Girl”. Surprisingly, in light of this anchor point and the demographic reality of the industry, Eliya presents her supervisor, a STEM-trained man, as head of a “harem of girls”. Eliya no doubt experienced the disparity of, on the one hand, being part of this “harem” and, on the other hand, being ‘The Only Girl’. Similar to Geirit, Eliya also walks this gendered fine-line acknowledging that the first two years of working in the Canadian space industry were difficult:

I was always a bit lost, I didn’t understand anything in meetings, acronyms, and it was complicated with [company #1], with [company #2] and the [specific man who yelled at me]. And I couldn’t ask [company #1] too many questions; there was no contractual agreement for them to be paid to answer my questions. So yeah, the guy [who yelled at me] was eventually removed. Sometimes I hear him in meetings. Not sure why he reappears [laugh].

Digging deeper into this “guy who yelled at me”, Eliya’s day-to-day interactions with certain individuals is challenging to say the least. The following two stories underscore her self-identified need to be “adaptable”, if she wishes to continue to work in an industry that condones such behavior:

[A specific company] gave us two people, one of whom everyone had warned me about – how it was hell working with him, how tons of people had quit because of him. He hates women, he has no emotional intelligence, he’s always back-stabbing – I heard this from everyone. I was insulted over the phone by a guy from [a specific company]. Apparently, he has an issue with girls at work. With [specific girl], there had previously been a concern. So, in fact, I found a problem on the [specific project] [...] and as he had worked on it, I asked him about it. He replied that it wasn’t his fault if I didn’t know my stuff, and it definitely wasn’t his job to train me, and so on. He had yelled so loudly that two offices down, behind closed doors, they had heard [...] Yeah, not only being young, but also being a girl, it wasn’t always easy.

Eliya's ability to navigate these types of interactions with individuals who have "issues with girls" reveals much about some of the barriers she faces on a daily basis. She believes she was yelled at because (1) she is a "girl" and, (2) as a "girl", she was asking too many questions. That it is acceptable that this individual should react to Eliya in this way does not seem to be an issue – if she wasn't a "girl" asking such questions, then she would not be yelled at. Yet as someone looking from the outside, you can perhaps see that it should not be Eliya who has to make sense of a co-worker's microaggressions; rather, the coworker himself should be the one asking why he is yelling at her or why he has issues with "girls at work".

6. Concluding Thoughts: Undoing Barriers to Space

The barriers to working in the Canadian space industry emerge not only through accounts of the historical influences of women in the space industry but also from the exploration of contemporary experiences of early-career STEM-trained women. Some of these contemporary experiences can be seen through such dominant practices as gendered educational barriers, women representing the "standard 20%" in technical positions, the need to develop resilience – including embracing merit above everything else and dealing with being yelled at – in the face of relentless change, deferring to boyfriend's wishes with respect to career choices, and navigating a variety of temporary anchor points that can position women below others. From the stories and narratives of two early-career STEM-trained women, we also learned about their specific experiences having to navigate the gendered fine-line, the teasing and the microaggressions that victimize them.

There is evidence, via the analysis of their discourses, that these early-career STEM-trained women do not yet see some of these barriers and these anchor points. As a case in point, Eliya "barely notices" when she is being "checked out at work. That's how it is for me now". Geirit's gendering 'The Bitch' anchor point, too, does not incite her to resist such a label; rather, she tries to move towards an acceptance of this anchor point, with a need to run to others to ask if she has, indeed, "overstepped" boundaries. Perhaps most worrisome, Eliya makes sense of being yelled at because she is "young" and a "girl" who asks (too many) questions. She appears to accept these microaggressions as reflective of her state of being a "girl". The question of how these barriers for early-career STEM-trained women come to be does not result in a cause-and-effect type of answer. Specifically, I did not look to make a causal link between if I call a STEM-trained woman 'The Bitch', she is or becomes the 'Bitch'. The empirical findings I share in this chapter support the notion that barriers are being erected and practiced on a daily basis in this industry, and this through multilayered activities including attributing anchor points, found in stories and narratives occurring in the everyday social interactions.

Although the identities surfaced in this study are momentary snapshots of what is going on in this industry, these snapshots also bring hope that such positioning experiences

can be undone. In other words, the barriers and anchor points do not have to be given life and reproduced repeatedly, if we take the time to recognize them. We can stop microaggressions, for example, by telling offenders that it's unacceptable to yell at an early-career STEM-trained woman or any woman for that matter. We can encourage organizations to work toward improved job stability in the industry, and to offer more tangible support for activities such as management skill development, career development skills, etc. To be clear, many early-career STEM-trained women working in the space industry are already highly trained, sometimes surpassing the training that men hold in this industry. The broader issue of resources to move into leadership positions needs to be examined, not just the issue of women-versus-men in management.

In closing, I challenge all in the space industry to construct identities, stories, and narratives that can disrupt the status quo and that do not position STEM-trained women below others, regardless of career stage. Let's be catalysts for change, part of a movement that acknowledges that barriers exist. Reveal these barriers, and take that "giant leap" to undo them.

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